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METHOD AND SYSTEM FOR RADIO COVERAGE PLANNING WITH LOCAL DOUBLE GRID APPROACH

TECHNICAL FIELD OF THE INVENTION

5   The present invention relates in general to radiocommunications network planning. In particular, the present invention finds an advantageous, but not exclusive, application in the planning of a radiocommunications network for mobile terminals,
10   comprising a number of (large or small) cells distributed over a particular geographical area or territory, to which the ensuing treatment will explicitly refer, without this entailing any loss of generality.

15

BACKGROUND ART

As is known, the first essential step of a process for designing and planning a radiocommunications network for mobile terminals is computing the so-called cell
20   coverage, i.e., extent and features of a region around a radio base station where radioelectric signals received by a mobile terminal and radiating out from the radio base station cope with given requirements.

Generally, this region is the locus of points where
25   the strength, or a quantity related thereto, of a radioelectric signal received by the mobile terminal and radiating out from the radio base station exceeds a given threshold. Such a threshold may be defined by using different criteria, the most adopted of which are
30   detectability of a reference channel in the radioelectric signal received by the mobile terminal, and transmission error rate higher than a threshold value.

Traditionally, one of the most frequently used
35   methods for computing cell coverage includes radially

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scanning the region around the radio base station along angularly equispaced radial scanning line connecting the radio base station and the point where one of the following three quantities, which, considered singularly, may be regarded as indicative of the cell coverage, is to be computed: the point strength of the radioelectric signal received by the mobile terminal, the local mean of the point strength of the radioelectric signal, and the median value of the local means of the point strength of the radioelectric signal.

The point strength is the value of the modulus (or envelope) of the radioelectric signal in a given point of the region, the dimensions of point being substantially equal to those of the physical element which is used to measure the point strength of the radioelectric signal: in this case, the mobile terminal antenna of few centimeters.

The local mean is the mean value of the point strength of the radioelectric signal within some tens of wavelengths long, which, having regard to the frequencies involved in mobile radiocommunications, results in considering paths 5 to 10 meters long or areas some tens of square meters wide.

The median value of the local means of the point strength of the radioelectric signal is a resumptive statistical value which, to guarantee a satisfying reliability (confidence) thereof, is to be computed by taking account of a congruous number of local means (10 to 20), which results in considering paths 50 to 100 meters long or areas few thousands of square meters wide.

Measuring the point strength of the radioelectric signal is not presently one of the key points in the development of radiocommunications network planning tools because of the extreme spatial variability of the

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radioelectric signal strength due to the "fine" structure (order of magnitude of the centimeter) of the surrounding environment.

5   Computing the local mean of the point strength of the radioelectric signal is, nowadays, still marginal in mobile radiocommunications network planning due to the modellization and computation complexity and to the huge amount of environmental data (cartographic database) to be processed.

10   This quantity is generally taken into account only during coverage computation for micro cells (cells with radio base stations arranged at few meters from the ground), which are characterized by narrow territorial extents (diameter of some hundreds of meters) and which

15   are the minority (about 10%) of the cells forming a typical mobile radiocommunications network.

Computation of this quantity is indeed hard to carry out for traditional cells, i.e. cells having a coverage area with a diameter of several kilometers,

20   such as large cells (cells with radio base stations arranged on isolated masts) or small cells (cells with radio base stations arranged on building roofs), due to the high computation time and, above all, to the low reliability of the results at these distances.

25   On the contrary, computing the median value of the local means of the point strength of the radioelectric signal plays a paramount role in the development of radiocommunications network planning tools because in most cases this quantity represents the physical

30   parameter associated with the concept of cell coverage. Therefore, nowadays the design of a mobile radiocommunications network is substantially based on a electromagnetic coverage prediction based on the median values of the local means.

35   A traditional cell coverage computation, sometimes

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also referred to as cell coverage prediction, is carried out by using a low environment resolution, i.e., by taking account of data describing the features of the environment within elementary areas, generally known as

5   pixels, having a side of 50 or 100 meters.

The median values of the local means of the point strength of the radioelectric signal along the scanning lines are computed by taking account of the power radiating out from the radio base station, a open

10   environment propagation curve, a morphological factor, a urbanization factor and an orographical factor (diffraction on natural obstacles).

In particular, the open environment propagation curve is indicative of the radioelectric signal strength

15   attenuation, also known as propagation loss, in a open area, i.e., an area empty of trees, buildings or architectural structures made by human beings, and is generally expressed as a semi-empiric relation as a function of the power radiating from the radio base

20   station antenna, antenna radiation pattern, distance from the radio base station and the mobile terminal, antenna tilt, radiation frequency, and effective antenna height with respect to the ground.

The orographical factor, urbanization factor and

25   the morphological factor are correction factors for the open environment propagation curve and describe, respectively, the altitude features of the geographical area, the building features within areas having selectable sizes (e.g. 50 by 50 meters), and the

30   geographical area in terms of morphological classes (forested, lakeside, etc.), which, as is known, influence radioelectric signal propagation.

In some cases, only morphological and u inization features within the pixel, for which computation of the

35   local means of the radioelectric signal strength is

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carried out, are taken into account, whereas in other cases, characterized by a more refined approach, these features all along the scanning lines are taken into account.

Lastly, computing diffraction on natural obstacles is the aspect that requires a more complex processing of the cartographic data. Starting from the orography, an altimetric profile is determined all along each scanning line, and the interaction effects (signal attenuation) with the possible natural obstacles arranged along the scanning lines are computed by resorting to the classic Huyghens-Fresnel theory, according to which such interaction effects may be assessed with adequate reliability by replacing each natural obstacle with an equivalent virtual obstacle (screen) having a knife edge shape, a height equal to the natural obstacle, an infinitesimal thickness, endlessly extending perpendicularly to the propagation direction, and perfectly absorbing the incident electromagnetic signal.

Other more advanced approaches are provided, instead, for computing diffraction on natural obstacles by resorting, rather than to an infinitesimal thick screen, to a finite thick screen having a rounded edge. However, the approaches based on an infinitesimal thick screen are the most frequently used because they are simple and are adapted to this specific problem on the basis of some known algorithms which have been derived from the literature and appropriately modified and optimized to take into account the effects due to multiple obstacles. Examples of such known algorithms are the Epstein-Peterson method, the Deygout method and the stretched string method, the latter being recommended by ITU-R 526 and being the best trade-off between result reliability and algorithm computational speed and thus the most frequently used.

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For a more detailed discussion of the low environment resolution cell coverage computation, the reader is referred to the following publications, which are incorporated herein by reference, in their entirety:

5   1) M. Hata, "*Empirical formula for propagation loss in land mobile services*", IEEE Trans. On Vehicular Technology, Vol. 29, 1980;

2) E. Damosso, L. Stola, "*Radiopropagazione*", Scuola Superiore Guglielmo Reiss Romoli, L'Aquila, 1992;

10   3) ITU-Reccommendations Rec. P. 526-3 "*Propagation by diffraction*";

4) G. Bussolino, R. Lanzo, M. Perucca, "*Rasputin: a field strength prediction model for large and small cell mobile system using territorial data base*", 7th

15   International Network Planning Symposium, Sidney 1996;

5) COST 235 "*Radiowave propagation effects on next generation fixed service terrestrial telecommunication systems*", Chap. 4, Final Report EUR 16992 EN, 1996.

The need for a growing number of radio base

20   stations, together with the need for more complete services, in particular services having features more and more detailed on a territorial level, has forced second and third generation mobile radiocommunications network providers to resort to a high environment

25   resolution network design which enables definition of specific design parameters for very narrow territory elements. For example, along a road or in a square given services may be provided rather than others and, in any case, services with a level appropriate to the specific

30   territorial, social and town reality.

The low environment resolution, which is typical of traditional mobile radiocommunications network design and planning, is evidently inadequate to cope with the above-mentioned needs, which may instead be partially

35   satisfied by using a high environment resolution, i.e.,

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by taking account of data describing the features of the environment within pixels having a side of 5 or 10 meters, which high environment resolution is more consistent with the dimensions of the town elements and,

5   at the same time, allows computing the local means of the point strength of the radioelectric signal.

A number of different methodologies for computing high resolution environment cell coverage on the basis of the local means of the point strength ·of the

10   radioelectric signal have been proposed.

For a detailed discussion of these methodologies, the reader is referred to the following publications, which are incorporated herein by reference, in their entirety:

15   1) EP-A-1 292 163, "Method for determining the values of the electromagnetic field generated by a radio base station in an urban environment";

2) M. Perucca, M. Signetti "Small cells planning analysis of electromagnetic models from measurements at

20   1800 MHz", ICAP 1997;

3) COST Action 231 "Digital mobile radio towards future generation systems", Chap 4, Final Report EUR 18957, 1999,

4) ITU – R Rec. 1411 "Propagation data and

25   prediction methods for the planning of short range outdoor radio communication systems and radio local area networks in a frequency range 300 MHz to 100 GHz";

5) US-A-2001/0041565 "Method and apparatus for network planning".

30   All of these methodologies, however, have been designed and developed for short distances from the radio base station, in particular distances shorter than 1 or 2 kilometers, and consequently they involve a territorial analysis which is entirely carried out using

35   a high environment resolution, i.e., considering pixels

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having a side of 5 or 10 meters.

Therefore, a paramount problem generally experienced in extending these approaches to large distances (10-20 km) is represented by the computation

5   time and, above all, by the result reliability. In particular, once the refinement level of the computation model has been fixed, the result reliability depends mainly on the number of interactions with the surrounding environment along the scanning line which

10 occur during computation of the local mean of the point strength of the radioelectric signal for the pixel considered. Inevitably, each interaction with the surrounding environment involves a given computation approximation and consequently a computation error which

15 accrues during the computation.

OBJECT AND SUMMARY OF THE INVENTION

The aim of the present invention is to provide a method, a system and a computer program module for

20 planning a radiocommunications network which enable exploiting, on the one hand, the entire low environment resolution cell coverage computation heritage available to the mobile radiocommunications network providers, and, on the other hand, the extensively tested and fully

25 reliable computation algorithms proposed for high resolution cell coverage computation.

This aim is achieved by the present invention in that it relates to a method, a system and a computer program module for planning a radiocommunications

30 network, as defined in claims 1, 24 and 25, respectively.

In particular, radiocommunications network planning according to the present invention envisages computing cell coverage, wherein computing cell coverage includes

35 dividing the region around the radio base station into a

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number of large environment pixels; computing, for each
large environment pixel, a first quantity indicative of
the coverage within the large environment pixel as a
function of data describing the environment within large

5   environment pixels along a propagation path of a
radioelectric signal radiating out from the radio base
station and passing through the large environment pixel;
dividing each large environment pixel into a number of
small environment pixels; and then computing, for each

10   small environment pixel, a second quantity indicative of
the coverage within the small environment pixel, the
second quantity being computed as a function of the first
quantity computed for the large environment pixel
containing the small environment pixel and of data

15   describing the environment within the small environment
pixel and within some further small environment pixels
within the large environment pixel and arranged upstream,
and close to the small environment pixel along a
radioelectric signal propagation path passing through the

20   small environment pixel.

    BRIEF DESCRIPTION OF THE DRAWINGS
        For a better understanding of the present
    invention, a preferred embodiment, which is intended

25 purely by way of example and is not to be construed as
    limiting, will now be described with reference to the
    attached drawings, wherein:
        - Figure 1 shows a work station programmed to allow
    radiocommunications network planning according to the

30 present invention;
        - Figure 2 shows a flow chart of the
    radiocommunications network planning method of the
    present invention;
        - Figure 3 shows, not in scale, a radio base

35 station, virtual radioelectric signal sources, a large

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environment pixel and small environment pixels within
the large environment pixel which are taken into account
during coverage computation carried out during the
radiocommunications network planning according to the
5   present invention;

- Figure 4 shows a composite altimetric profile
computed during radiocommunications network planning;

- Figure 5 shows a small environment pixel
including a road junction;

10   - Figure 6 shows large environment pixels
surrounding a large environment pixel for which high
environment resolution coverage is computed; and

- Figure 7 shows small environment pixels occupied
by a building and for which high environment resolution
15   coverage is computed.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS OF
THE INVENTION

The following discussion is presented to enable a
20   person skilled in the art to make and use the invention.
Various modifications to the embodiments will be readily
apparent to those skilled in the art, and the generic
principles herein may be applied to other embodiments
and applications without departing from the spirit and
25   scope of the present invention. Thus, the present
invention is not intended to be limited to the
embodiments shown, but is to be accorded the widest
scope consistent with the principles and features
disclosed herein and defined in the attached claims.

30   Figure 1 shows a processing system for planning a
radiocommunications network for mobile terminals. The
processing system, designated as a whole by 1,
essentially comprises a work station 2, for example a
Hewlett Packard J5000 with a 450 MHz CPU, 1 Gbyte RAM,
35   18 Gbyte hard disk and UNIX operating system, having a

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central processing unit 3 connected to a local area
network 4, an internal hard disk (not shown) storing
reference databases, a display 5, a keyboard 6 and a
mouse 7. Should the databases exceed the hard disk
5   storage capacity, the work station 2 may also be
provided with an external hard disk 8 connected to
central processing unit 3 directly or through the local
area network 4.

     The work station 2 is configured to allow
10   radiocommunications network planning on the basis of
computer program modules which run on the central
processing unit 3 and implementing the planning method
in accordance with the present invention, with the aid
of the reference databases stored in the internal hard
15   disk or in the external hard disk 8.

     Broadly speaking, the brainwave at the basis of the
present invention is to compute cell coverage by using a
double environment resolution, i.e., first of all to
compute cell coverage by using a traditional low
20   environment resolution, i.e. by considering large
environment pixels, for example having a side of 50-100
meters, e.g. 50 by 50 meters, thus exploiting the known
techniques for large scale cell coverage computation,
and then to compute cell coverage by using a high
25   environment resolution, i.e. by considering small
environment pixels, for example having a side of 5-10
meters, e.g. 5 by 5 meters.

     In particular, low environment resolution coverage
is computed by dividing the region around the radio base
30   station into a number of large environment pixels, and
then computing, for each large environment pixel for
which low environment resolution coverage computation is
needed, a first quantity (median value of the local
means of the point strength of a radioelectric signal)
35   indicative of the coverage within the large environment

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pixel, whereas high environment resolution coverage is
computed by dividing each large environment pixel into a
number of small environment pixels, and then computing,
for each small environment pixel for which high
environment resolution coverage computation is needed, a
second quantity (local mean of the point strength of a
radioelectric signal) indicative of the coverage within
the small environment pixel, the second quantity being
computed as a function of the first quantity computed for
the large environment pixel containing the small
environment pixel and of data describing the environment
within the small environment pixel and within some
further small environment pixels within the large
environment pixel and arranged upstream, and close to
the small environment pixel along a radioelectric signal
propagation path passing through the small environment
pixels.

In a preferred embodiment, the second quantity for
a small environment pixel is computed also as a function
of data describing the environment within some further
small environment pixels arranged just outside the large
environment pixel containing the small environment pixel
and upstream the small environment pixel along a
radioelectric signal propagation path passing through
the small environment pixels.

In a further preferred embodiment, the second
quantity for a small environment pixel is computed also
as a function of the first quantities computed for the
large environment pixels which surround the large
environment pixel containing the small environment
pixel.

In a further preferred embodiment, the second
quantity for a small environment pixel is computed by
arranging a number of virtual radioelectric signal
sources outside the large environment pixel containing

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the small environment pixel, and then computing the
second quantity as a function of the point strength of a
radioelectric signal radiating out from at least one of
the virtual radioelectric signal sources and having a
5   propagation path passing through the small environment
pixel.

In this preferred embodiment, thanks to the fact
that the first quantity for the large environment pixel
has already been computed during the low environment
10   resolution cell coverage computation, the virtual
radioelectric signal sources may be configured to
radiate any reference power. In fact, the second
quantities computed for the small environment pixels
within a large environment pixel as a function of the
15   reference power radiated by the virtual radioelectric
signal source may be simply scaled (up or down) so that
their average value within the large environment pixel
be equal to the first quantity computed for the large
environment pixel.

20   A preferred embodiment of the present invention
will now be described with reference to Figures 2 and 3,
considering a large environment pixel of 50 by 50
meters, and preferably made up of 100 small environment
pixels of 5 by 5 meters. These values have been
25   considered appropriate in view of the 2 GHz frequency
band which will be used in the future third generation
mobile radio communication networks.

The radiocommunications network planning method
according to the present invention involves executing
30   the following steps which will be described with
reference to the flow chart of Figure 2.

The first step is computing cell coverage by using
a traditional low environment resolution (block 100). In
particular, such a traditional low environment
35   resolution cell coverage computation may be carried out

either by accessing an electronic data bank containing data relating to a traditional low environment resolution cell coverage already computed for the mobile radiocommunications network or portion thereof where

5   high environment resolution cell coverage is to be computed, or, where such an electronic data bank is not available or not satisfactory, by carrying out a traditional low environment resolution cell coverage computation, i.e. by dividing the region around the

10 radio base station into a number of large environment pixels, and then computing, for each large environment pixel, a first quantity indicative of the coverage within the large environment pixel.

Conveniently, such a traditional low environment

15 resolution cell coverage computation may be based on the methodology disclosed in the above-mentioned publication "*Radiopropagazione*", which is the most suitable for urban areas because it is capable of taking into account the effects due to the territory features (orographical,

20 urbanization and morphological factors).

In particular, to implement such a methodology, the following environment data are to be provided to the model for each large environment pixel: ground altitude with respect to the sea level, average building height,

25 area of the large environment pixel occupied by buildings (in percentage), and appropriately coded vegetation typology.

The second step is computing high environment resolution coverage, which computation involves

30 executing a number of steps which have to be repeated for each large environment pixel where such a high environment resolution coverage computation is desired.

Broadly speaking, high environment resolution coverage computation involves dividing a large

35 environment pixel into a number of small environment

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pixels, and computing, for each small environment pixel within the same large environment pixel and for which such a high environment resolution coverage computation is desired, a second quantity indicative of the coverage

5   within the small environment pixel.

In particular, the first step of the high environment resolution coverage computation is preparing high resolution environment data necessary to coverage computation by using high environment resolution (block

10   110). In particular, preparing high resolution environment data includes extracting, from a digital cartography database, high resolution environment data relative to the small environment pixels within the selected large environment pixel for which high

15   environment resolution coverage computation is needed.

To improve high environment resolution coverage computation within a large environment pixel, preparing high resolution environment data may also include extracting, from the digital cartography database, high

20   resolution environment data relative to an external area surrounding the large environment pixel.

In more detail, high resolution environment data include ground altitude with respect to the sea level and building height (if any) with respect to the ground

25   level. In a preferred embodiment, from the digital cartographic database there are extracted 200 values (100 for altitudes and 100 for building heights) relative to the selected large environment pixel, and 312 values (156 for altitudes and 156 for building

30   heights) relative to an external annular area around the large environment pixel and having a width of three small environment pixels.

When the high resolution environment data have been extracted, high environment resolution coverage is

35   computed for this large environment pixel (block 120).

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In particular, high environment resolution coverage computation envisage replacing the radio base station with some sort of wave front of a radioelectric signal radiating therefrom as it is in a given location outside

5   the large environment pixel. In more detail, such a sort of wave front of the radioelectric signal radiating from the radio base station is simulated by arranging a number of virtual radioelectric signal sources (array of electromagnetic feeds) having a particular pattern in

10 said given location outside the large environment pixel.

Figure 3 shows, not in scale, the virtual radioelectric signal sources VRSS, the radio base station RBS, a large environment pixel LEP, depicted in grey and bordered by a bold line, the small environment

15 pixels SEP within the large environment pixel LEP, the annular area AE surrounding the large environment pixel LEP, and the small environment pixels SEP within the annular area AE.

As is shown in Figure 3, the virtual radioelectric

20 signal sources VRSS are equispatially arranged along a circumference arc having:
- center in the radio base station RBS,
- radius R equal to the difference between the distance between the radio base station RBS and the

25 center C of the large environment pixel LEP and the distance between the center C of the large environment pixel and the circumference arc, and
- ends A e B which lie respectively on the lines linking the radio base station RBS and the corners of

30 the large environment pixel LEP corresponding to the minimum and maximum azimuth angles φ_{min}, φ_{max} thereof with respect to the radio base station RBS.

Furthermore, the distance between two adjacent virtual radioelectric signal sources VRSS along the arc

35 is substantially equal to the side of a small

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environment pixel SEP, i.e., about 5 meters in the
preferred embodiment considered, and the height of the
virtual radioelectric signal sources VRSS is equal to
the sum of the ground altitude with respect to the sea
5   level and the average building height within the large
environment pixel LEP.

Furthermore, in a preferred embodiment the distance
between the center C of the large environment pixel LEP
and the circumference arc along which the virtual
10   radioelectric signal sources VRSS are arranged is equal
to the diagonal of the large environment pixel LEP,
i.e., about 70 meters in the preferred embodiment
considered.

Lastly, consistently with the aforementioned
15   criteria, in the preferred embodiment considered, the
number of the virtual radioelectric signal sources VRSS
is equal to 15.

The aforementioned values are then used to compute
high environment resolution coverage for the selected
20   large environment pixel, which computation is
essentially carried out by resorting to a solution based
on diffraction elements of the type disclosed in the
aforementioned *"Small cells planning analysis of
electromagnetic models from measurements at 1800 MHz"*.

25   In particular, a fundamental difference with
respect to what is disclosed in the aforementioned
publication lies in the pixel scanning methodology. In
fact, having regard to fact that the radio base station
has been replaced with a number of virtual radioelectric
30   signal sources, the scanning methodology is not based
anymore on radial scanning lines originating from the
radio base station, but instead on scanning lines
originating from the virtual radioelectric signal
sources and being the prolongation of theoretical lines
35   linking the radio base station and the virtual

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radioelectric signal sources.

According to an aspect of the present invention, high environment resolution coverage is computed only for those small environment pixels which do not contain buildings. Figure 5 shows a large environment pixel LEP containing a road junction, wherein the small environment pixels SEPB depicted in grey represent presence of buildings, whereas the other small environment pixels SEPA represent absence of buildings. Consistently with the aforementioned criteria, high environment resolution coverage is computed only for the small environment pixels SEPA.

In detail, high environment resolution coverage computation envisages computing, for each of said small environment pixels, the local mean of the point strength, within the small environment pixel, of a radioelectric signal radiating out from a virtual radioelectric signal source and having a propagation path (scanning line) passing through the small environment pixel.

To do so, starting from the external area surrounding the large environment pixel and moving along the scanning line with a step equal to half of the side of the small environment pixel, i.e., 2.5 meters in the embodiment considered, a composite high environment resolution altimetric profile of the type shown in Figure 4 is computed as a function of the ground altitude with respect to the sea level and of the building height with respect to the ground altitude.

To determine attenuation by diffraction due to the buildings arranged along the scanning line, a propagation model based on the above-described Huygens-Fresnel theory is used, which theory, as initially said, envisages replacing each obstacle (in the present case predominantly represented by buildings) with an ideal

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screen, i.e. by a half-plane made of perfectly absorbent
material and having an infinitesimal thickness in the
propagation direction and an infinite length in a
perpendicular direction. This approximation of the
5   original obstacle is commonly known as "knife edge
obstacle", which has an height equal to the original
object (building or orographic maximum) and is arranged
exactly in the center of the original obstacle.

To predict the diffraction effects the method
10   disclosed in the aforementioned "Propagation by
diffraction" (ITU -Reccommendations Rec. P. 526-3) may
conveniently be used, together with the so-called
stretched string technique for identifying obstacles,
defined in the aforementioned ITU-Recommendations,
15   according to which only obstacles, denoted by rows in
Figure 4, which "touch" an ideal stretched string
extending between the virtual electromagnetic source
VRSS and the small environment pixel SEP for which
computation is being carried out are taken into
20   consideration.

According to another aspect of the present
invention, the virtual radioelectric signal sources may
radiate any generic reference power (e.g. 1 dBm) since
the average strength (median value) of the radioelectric
25   signal within the selected large environment pixel has
already been computed during the previous low
environment resolution cell coverage computation. In
fact, the local means of the point strength of the
radioelectric signals radiating out from the virtual
30   radioelectric signal sources may be simply scaled (up or
down, depending on the relationship between the power
radiated by the radio base station and the power
radiated by the virtual radioelectric signal sources) in
such a manner that their average value within the large
35   environment pixel be equal to the median value computed

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during the previous low environment resolution coverage
computation carried out for the large environment pixel.

In a preferred embodiment, the coverage (local
means) computed within the small environment pixels
5   within the same large environment pixel have to be
scaled by using a scaling factor K which is computed as
a function of the coverage (median value) within the
selected large environment pixel and the coverage (local
means) within the small environment pixels computed by
10   configuring the virtual radioelectric signal sources to
radiate a generic reference power, according to the
following formula:

$$K = \frac{E^{LR}}{\dfrac{1}{N_{max}} \cdot \sum_{j=1}^{N_{max}} E_j^{IR}}$$

15   wherein:
      - E^{LR} is the coverage (median value) within the
large environment pixel (the median value being
approximately comparable to the average value of the
local means);
20   - E_j^{IR} is the coverage (local mean) within the i-th
small environment pixel computed by assigning a generic
reference power to the virtual radioelectric signal
sources (e.g. 1 dBm); and
      - N_{max} is the total number of small environment
25   pixels within the large environment pixel (100 in the
preferred embodiment described).

In another preferred embodiment, in order to
smoothen the passage from a large environment pixel to
an adjacent one in terms of coverage, i.e., to prevent
30   two adjacent small environment pixels arranged across
the border line between two adjacent large environment
pixels from having a big difference in coverage due to

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the possible big difference in coverage between the two
adjacent large environment pixels, the scaling factor K
may be computed not only as a function of the coverage
(median value) within the selected large environment
5   pixel and the coverage (local means) within the small
environment pixels computed by configuring the virtual
radioelectric signal sources to radiate a generic
reference power, but also as a function of the coverage
(median value), appropriately weighted, within the eight
10   large environment pixels surrounding the selected large
environment pixel, according to the following formula:

$$K_i = \frac{E_i^{LR}}{\frac{1}{N_{max}} \cdot \sum_{i=1}^{N_{max}} E_i^{HR}}$$

where:

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$$E_i^{LR} = \frac{1}{D_i} \cdot \sum_{j=1}^{9} \left(\frac{1}{d_{i,j}} \cdot E_j^{LIR} \right)$$

$$D_i = \sum_{j=1}^{9} \frac{1}{d_{i,j}}$$

and wherein:

- E_i^{LR} is the coverage (median value) computed for
20   the selected large environment pixel also as a function
of the eight large environment pixels surrounding the
large environment pixel;

D_i is a normalization factor relative to the small
environment pixel;

25   $d_{i,j}$ is the distance between the i-th small
environment pixel (left bottom corner of the pixel) and
the center of the j-th large environment pixel;

E_i^{HR} is the coverage (local mean) within the i-th
small environment pixel;

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E_j^{LR} is the coverage (median value) within the j-th large environment pixel; and

- N_{max} is the total number of small environment pixels within the large environment pixel (100 in the preferred embodiment described).

In other words, as shown in Figure 6, the coverage (local mean) computed for a small environment pixel SEP, depicted in grey, within a large environment pixel LEP0 by assigning a generic reference power to the virtual radioelectric signal sources VRSS is multiplied by a scaling factor K which depends on the coverage (median value) computed for the large environment pixel LEP0, on the coverages (median values) computed for the eight large environment pixels LEP1-LEP8 surrounding the large environment pixel LEP0, and on the distance R between the small environment pixel SEP and the large environment pixels LEP0-LEP8. In particular, the coverages computed for the large environment pixel LEP0-LEP8 are weighted by using respective weights which are inversely proportional to the distances between the small environment pixel SEP and the centers of the large environment pixels LEP0-LEP8. In this way, it is evident that the bigger is distance between a large environment pixel LEP and the small environment pixel SEP, the smaller is the influence that this large environment pixel LEP exerts on the small environment pixel SEP. It is therefore evident that the coverage computed for a small environment pixel SEP is more influenced by the coverage computed for the large environment pixel LEP containing the small environment pixel SEP and by the coverages computed for the large environment pixels LEP which are closer to the small environment pixel SEP.

Once the high environment resolution coverage for the selected large environment pixel is computed, another large environment pixel is selected, if any

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(blocks 130 and 140), and the high environment
resolution coverage computation previously described
with reference to blocks 110 and 120 is repeated for the
large environment pixel newly selected. When high
5   environment resolution coverage has been computed for
all large environment pixels for which high environment
resolution coverage computation is needed, the latter
ends.

     To roughly predict the computational load, let's
10   consider a situation in which a number of virtual
radioelectric signal sources are arranged along a
circumference arc 70 meters long and are 5 meters spaced
apart (equal to the side of the small environment
pixel). In this situation, 15 virtual radioelectric
15   signal sources are provided, from each of which a
scanning line 50 meters long originates (medium
thickness of a large environment pixel with a side of 50
meters under a generic illumination angle). This
situation involves, for each large environment pixel, a
20   computational load equivalent to a high environment
resolution computation of a scanning line 750 meters
long.

    A traditional approach, on the contrary, involves a
computation entirely carried out at a high environment
25   resolution along the scanning lines between the radio
base station and the small environment pixels (with
angular and radial steps suitable for computing
representatively the whole area). It is therefore
evident that the double environment resolution
30   computation is far more efficient than a single
environment resolution computation, at least starting
from distances greater than 750 meters from the radio
base station.

    It is useful to point out that, for typical
35   coverage areas with a radius of 30 km, the area within

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which such benefits in terms of efficiency with respect
to a traditional approach may be obtained, is more than
99.9% of the whole coverage area.

Another aspect of the present invention is the way
5   of computing coverage within a building which occupies
some small environment pixels. In view of the complexity
of the propagation phenomena induced by this particular
physical conditions, this specific topic is commonly
addressed in the prior art by hypothesizing, on a
10   statistical basis, a single additional penetration
margin for the entire building, if necessary
appropriately differentiated by environment typology
and/or building typology, which is added to the coverage
(median value of the local means of the point strength
15   of the radioelectric signal) computed for the small
environment pixels but considering the environment open,
i.e., empty of buildings.

From an experimental point of view, this common
approach envisages measuring the average point strength
20   of radioelectric signals outside the building (for
example along the perimeter of the building, at ground
level) and then adding the hypothesized penetration
margin. From a modellistic point of view, instead, this
approach implicitly involves a low resolution coverage
25   computation for the large environment pixels occupied by
the building, i.e., involves computing the median values
of the local means of the point strength of a
radioelectric signal within the large environment pixels
occupied by the building by using low resolution
30   environment data (percentage of each large environment
pixel occupied by the building).

This approach is not compatible with a high
environment resolution coverage computation because, in
view of the size of the small environment pixels, the
35   percentage of each small environment pixel which is

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occupied by a building would be 0 or 100% (absence or
presence of a building).

    Therefore, instead of hypothesizing a single
additional penetration margin to be added to the
5   coverage computed for the large environment pixels
occupied by the building, as shown in Figure 7 the
coverage (local mean of the point strength of a
radioelectric signal) for each small environment pixel
SEPB occupied by the building, depicted with a
10   geometrical pattern, is computed as a function of the
coverages computed for the small environment pixels
SEPAS, depicted in grey, surrounding the small
environment pixels SEPB. In particular, as shown in
Figure 7, coverage for a small environment pixel SEPB
15   occupied by a building is computed as a weighted average
of the coverages computed for the small environment
pixels SEPA surrounding the small environment pixel
SEPB, and such coverages are weighted by using
respective weights which may for example be inversely
20   proportional to the squared distances $(1/r^2)$ between the
centers of the small environment pixel SEPB and the
small environment pixels SEPA surrounding the small
environment pixel SEPB. Obviously, other weights may be
used, all however having values which reduce as the
25   distance increases.

    Finally, it is clear that numerous modifications
and variants can be made to the present invention, all
falling within the scope of the invention, as defined in
the appended claims.

30   For example, high environment resolution coverage
computation may be carried out either for all large
environment pixels around the radio base station or for
only some of them, and, within a large environment
pixel, for all small environment pixels or for only some
35   of them, depending on the needs of the mobile

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radiocommunications network provider.

Furthermore, high environment resolution coverage computation for a given small environment pixel within a selected large environment pixel may be carried out as a function of data describing the environment within either all small environment pixels located upstream said given small environment pixel along the radioelectric signal propagation path passing through the given small environment pixel and within the selected large environment pixel, or only some of them, depending on the reliability which is needed for the high environment resolution coverage computation . In the latter case, it may be convenient to take account of data describing the environment within the small environment pixels closer to the given small environment pixel.

Moreover, the virtual radioelectric signal sources may be arranged side by side not only along a circumference arc, but also along any type of line, for example a generally curved line or a straight line.

Lastly, data describing the environment within large and small environment pixels may be different than the ones described above.